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ON THE APPLICATION OF INFORMATION TECHNOLOGY FOR THE DEVELOPMENT OF SOFTWARE FOR AUTOMATION THE MODELING PROCESS OF WAGONS AT WAGON ENTERPRISES JSC "O'ZBEKISTON TEMIR YO'LLARI"

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Abstract: The report presents a functional diagram of the developed software for calculating the values of loads acting on the wagon body. The stages of development and the main modules of a software product that implements mathematical calculations are defined. The issues of the software implementation of the presented algorithms using the object-oriented programming language C # are discussed. The performed engineering analysis using the values of loads obtained using the developed software is given. The developed program in C # language with the use of the integrated Visual Studio environment allows to increase the accuracy and reduce the time for calculating the loads acting on the body of a freight car during strength calculations with various initial technical and economic characteristics and design features of freight cars.

Key words: wagon building, freight wagon, metal construction, modeling, load, strength, automation, schematic diagram, algorithm, programming, the correctness, automation.

О ПРИМЕНЕНИИ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ ДЛЯ РАЗРАБОТКИ ПРОГРАММНОГО ПРОДУКТА ПО АВТОМАТИЗАЦИИ ПРОЦЕССОВ МОДЕЛИРОВАНИЯ КОНСТРУКЦИЙ ВАГОНОВ НА ВАГОНОСТРОИТЕЛЬНЫХ ПРЕДПРИЯТИЯХ АО «УЗБЕКИСТОН ТЕМИР ЙУЛЛАРИ»

Аннотация: В статье приводится функциональная схема разработанного программного обеспечения для вычисления величин нагрузок, действующих на кузов вагона. Определены этапы разработки и основные модули программного продукта, реализующего математические вычисления. Обсуждаются вопросы особенности программной реализации представленных алгоритмов с помощью объектно-ориентированного языка программирования C#. Разработанная программа на языке C# с применением интегрированной среды Visual Studio позволяет повысить точность и сократить сроки вычисления нагрузок, действующих на кузов грузового вагона при прочностных расчетах с различными исходными технико-экономическими характеристиками и конструкционными особенностями грузовых вагонов.

Ключевые слова: вагоностроение, грузовой вагон, металлоконструкция, моделирование, нагрузка, прочность, автоматизация, принципиальная схема, алгоритм, программирование.

Introduction. In the process of designing and developing a new type of rolling stock, it is necessary to check the compliance of the strength characteristics of their structures with the established requirements [1-5]. The main documents are “Norm ...” [6] and GOST 33211 [7], which contain criteria for assessing the strength of the structure of a freight wagon body.

Relevance and analysis of the problem. To improve the quality of design and reduce the time required for theoretical and experimental research and development of new types of manufactured railway products, a clear advantage is the automation of the process of modeling new wagon designs and the introduction of a digital prototype at wagon-building enterprises using information technologies [8-11].

In order to automate the calculation of loads acting on the body of a freight wagon, with strength calculations with further three-dimensional modeling, special software was developed that satisfies and complies with the following conditions [6-7]:

- mapping of the field to display the source data;
- function of checking the correctness of the entered values;
- unction to perform the calculation and obtain results;
- block for the resulting parameters;
- field cleaning function;
- block combination of loads acting on the wagon body;
- reference block;
- software should not require the installation of additional libraries and plug-ins;
- software must have an intuitive graphical interface and the ability to use it on any computers with Windows preinstalled.

Theoretical part. When developing software to determine the loads acting on the body of freight wagons, at the initial stage, a schematic diagram of the program and the general algorithm of work [10] were built. The developed schematic diagram was created according to the modular principle and makes it possible in the future to expand its functionality by adding additional modules to determine other technical and economic parameters of the wagons. A detailed schematic diagram of the software for determining the loads acting on the body of freight wagons is shown in Fig. 1.

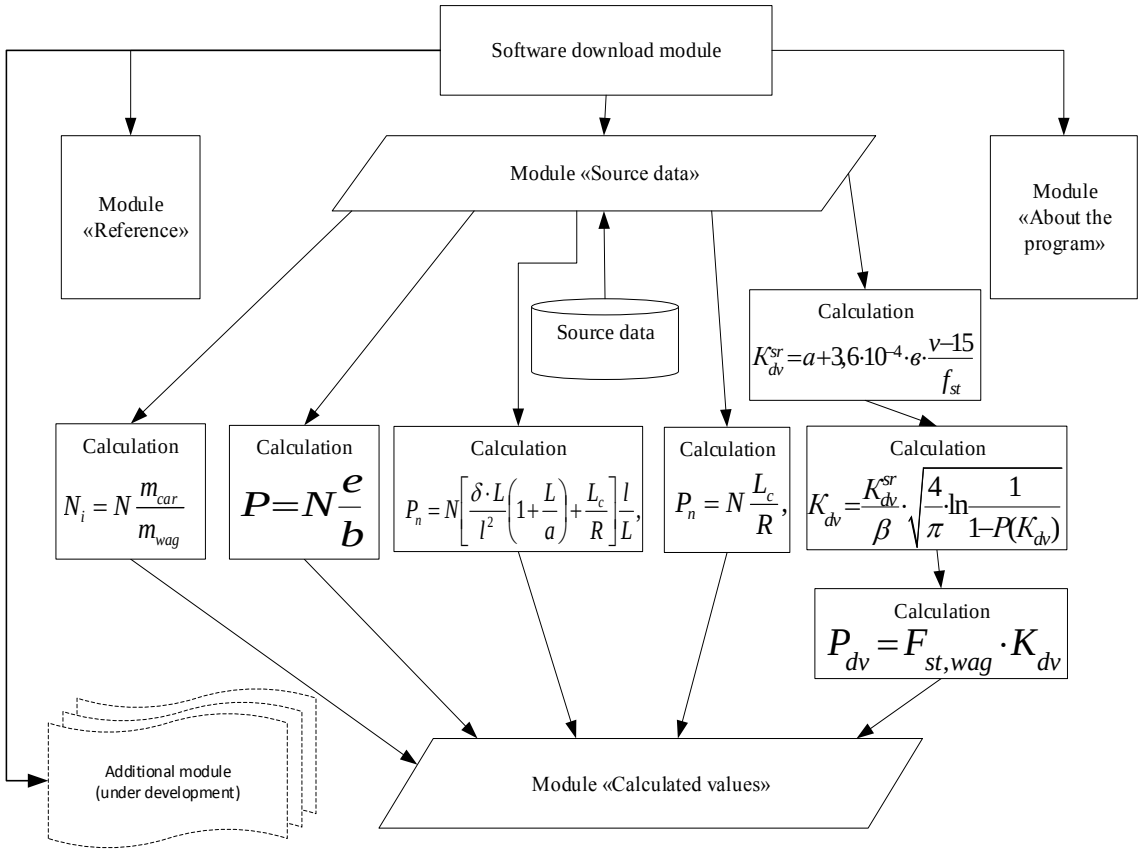

Figure 1. Schematic diagram of the software to determine the loads acting on the body of freight wagons

The software consists of modules, each module corresponds to a specific form and contains procedures. The module starts working immediately after the previous module finishes its work, or when the user calls it by clicking on the corresponding tab [11].

The software algorithm can be divided into several main blocks: the definition of source data; validation of the source data; completing the task and obtaining the results (Fig. 2).

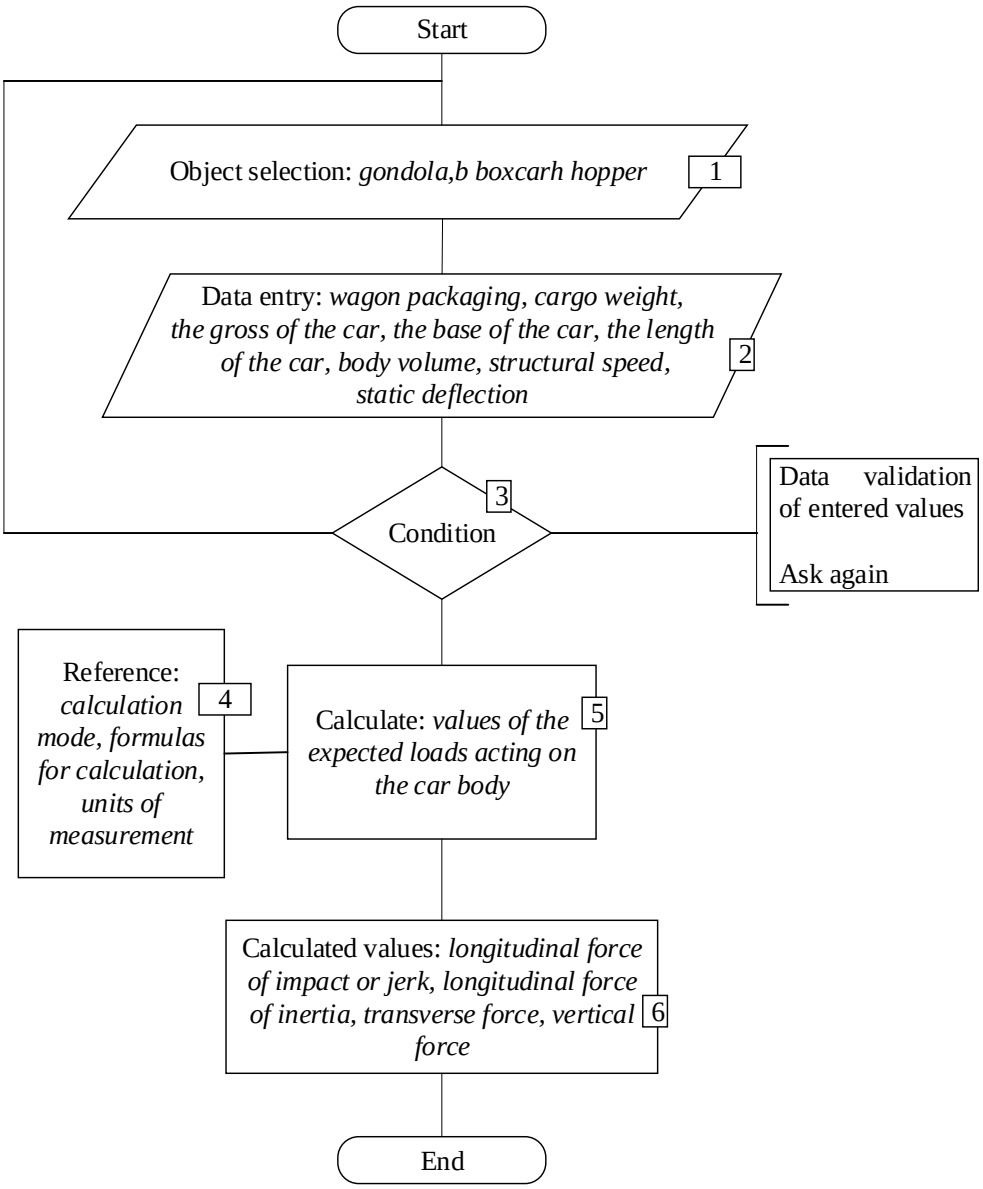

Figure 2. General software algorithm

In the first block, the wagon type is selected from the presented list. In the second block, the input data is entered. In the third block, the input data is checked. When determining incorrect data, it is necessary to re-verify the entered data and enter their correct values in the second block. If necessary, you can contact the reference block - the fourth block.

If a decision is made on the correctness of the values, the process is transferred to the fifth block. If all data is entered correctly, the verification process ends and is transferred to execution. The sixth block displays the results of the calculated values.

As a result of analyzing the tools and programming language intended for implementing software for calculating loads acting on the body of a freight wagon, it was decided to use the C# programming language using the integrated development environment Visual Studio [12-15].

Practical significance. The appearance of the boot process after the launch of the developed software is shown in Fig. 3 [15-17].

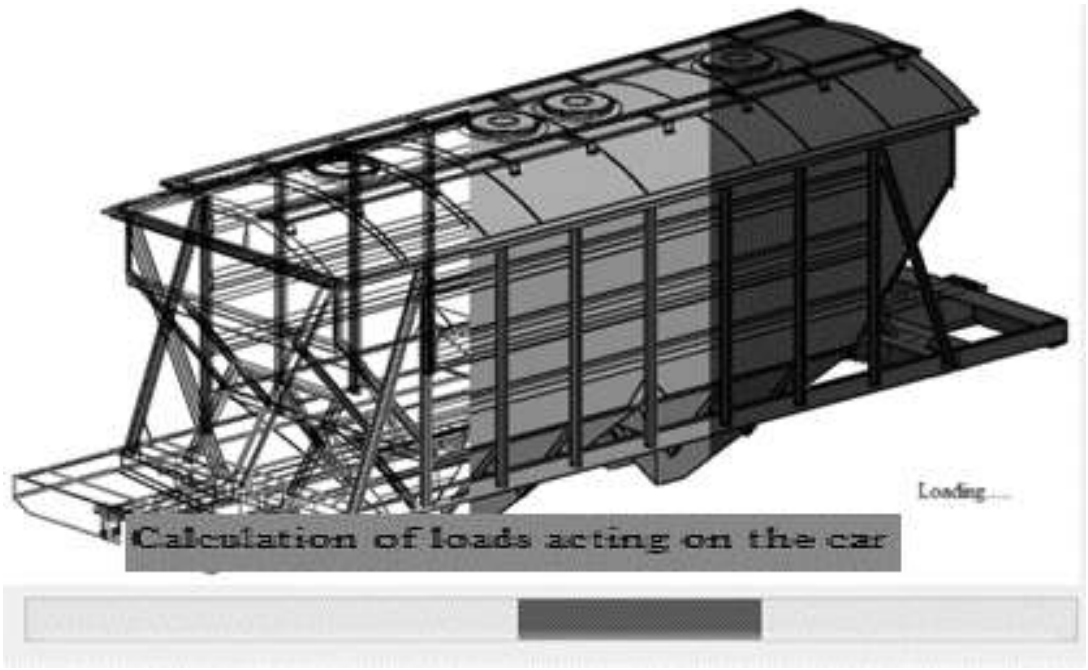

Figure 3. Appearance of the program loading process

In the main window there are several tabs, in which there are all the necessary cells (fields) for entering the initial data. The main software window is shown in Fig. 4.

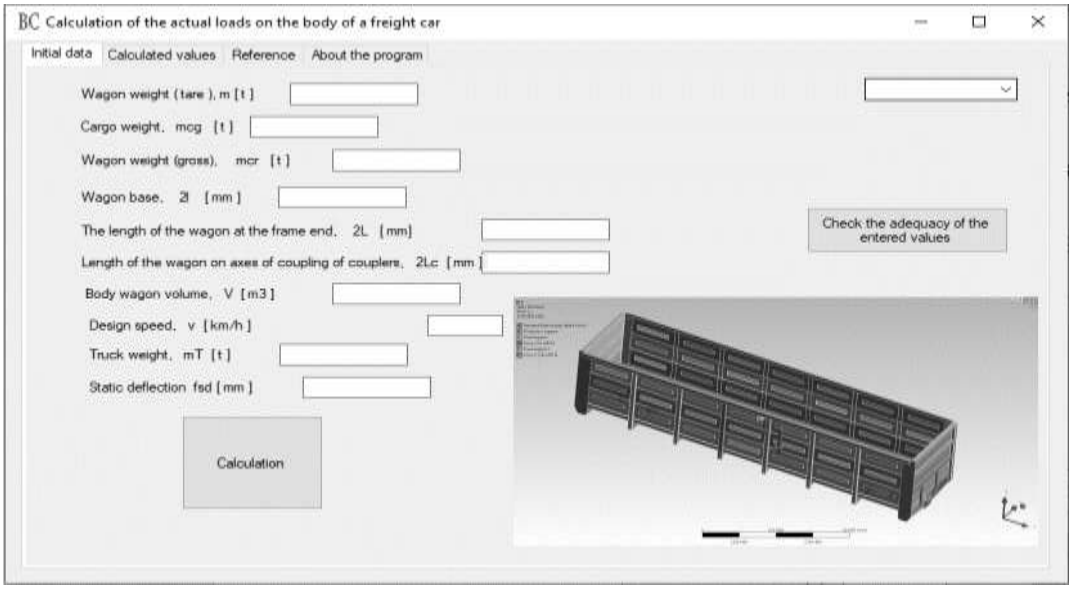

Figure 4. The main window of the program (before entering the initial data)

In the main program window on the tab, "Source data" are displayed:

- fields for filling in values with descriptions;
- field to select the type of wagon;
- button to check the adequacy of the input data;
- area of information about the examined wagon;
- button to complete the task.

When you hover the mouse pointer over the “Wagon Type” element, the user can select the type of the wagon under investigation from the menu.

Before performing the calculation, it is advisable to check the correctness of the entered values by clicking on the button “Checking the adequacy of the entered values”. If at least one of the fields has non-numeric data entered (or no data is entered at all), the program will give the user the corresponding message “Empty fields or incorrect values!!!” (Fig. 5).

```
Snippet of code to verify the adequacy of the input data
for(int k=1;k<=2;k++) {
String ^temp; int len;
switch(k) {
case 1:{temp=SizeG0->Text; len=SizeG0->Text->Length; break;}
case 2:{tem p=SizeG1->Text; len=SizeG1->Text->Length; break;}
}
if(len==0){result->Text="Error input size"; … return false;}
for(int i=0;i<len;i++) {
int j=0;
while(j<10 && temp->Substring(i,1)!=Convert::ToString(j)){j++;}
if(j==10){result->Text="Error input size"; … return false;} } }
```

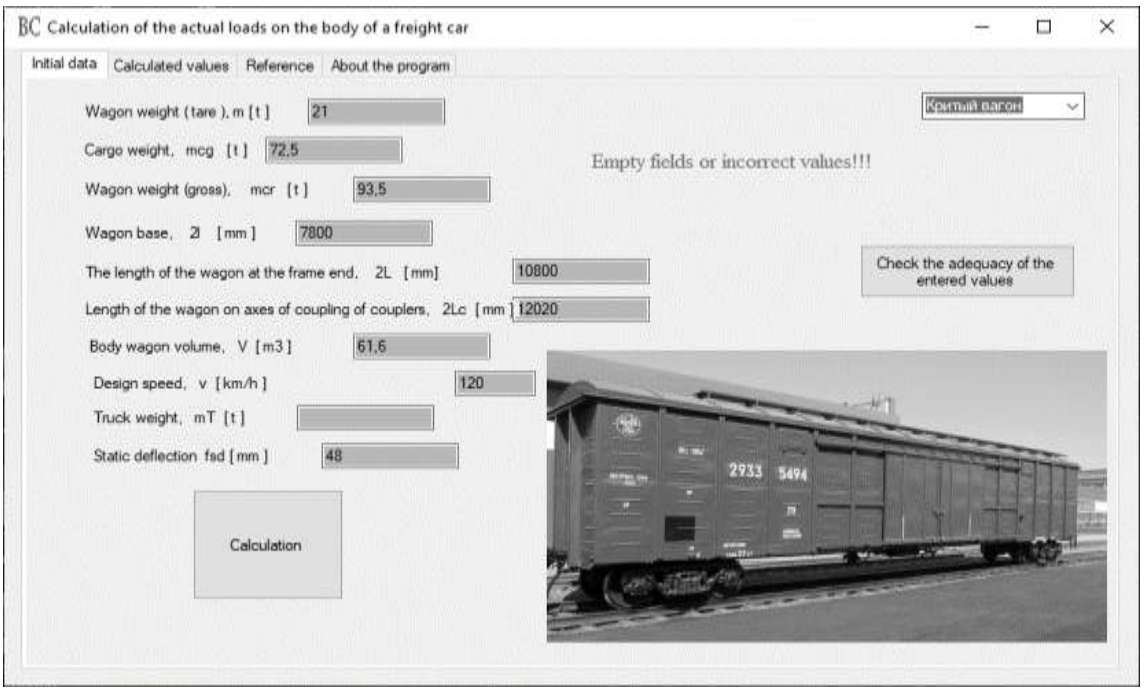

Figure 5. Validation of the entered data

To edit inconsistent source data, select and highlight the area in which the edited data is located. After selecting the area, enter the correct values of the source data.

If the correct values of the initial data are entered in all the fields, when you click on the “Calculate” button, the calculation is performed, and the message “Successfully completed!” Appears in the form (Fig. 6). Calculated values are available on the corresponding tab.

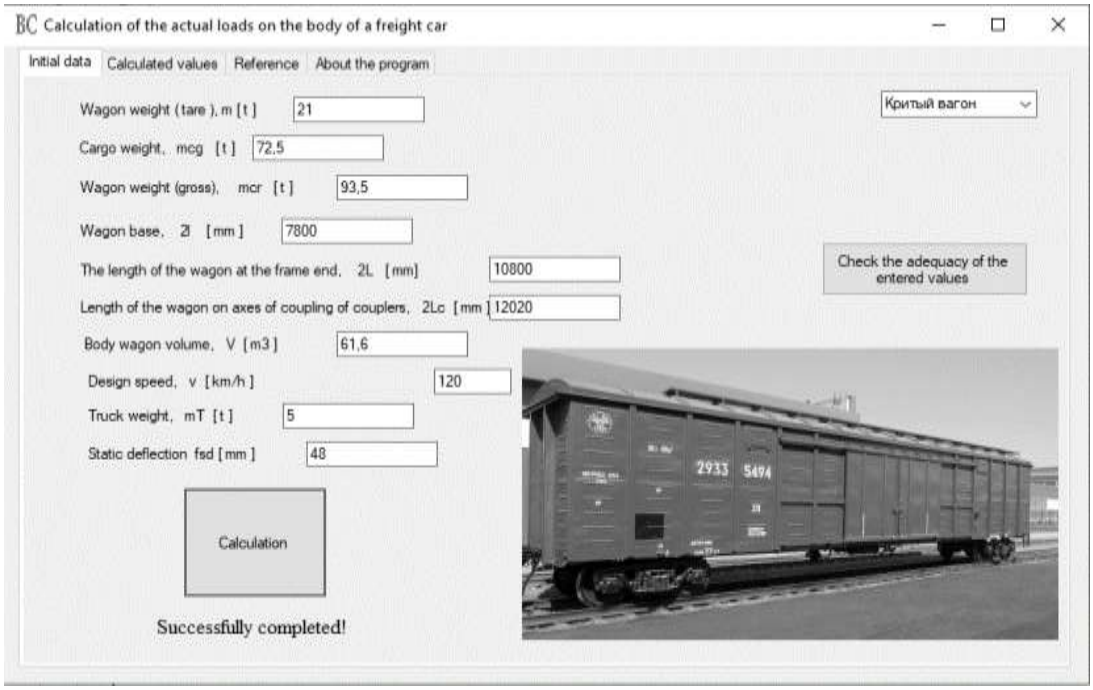

Figure 6. The process of performing the calculation

The Calculated Values tab displays the results of loads acting on the body of the freight wagon (Fig. 7). The calculation results are rounded when rendering to two decimal places after the comma.

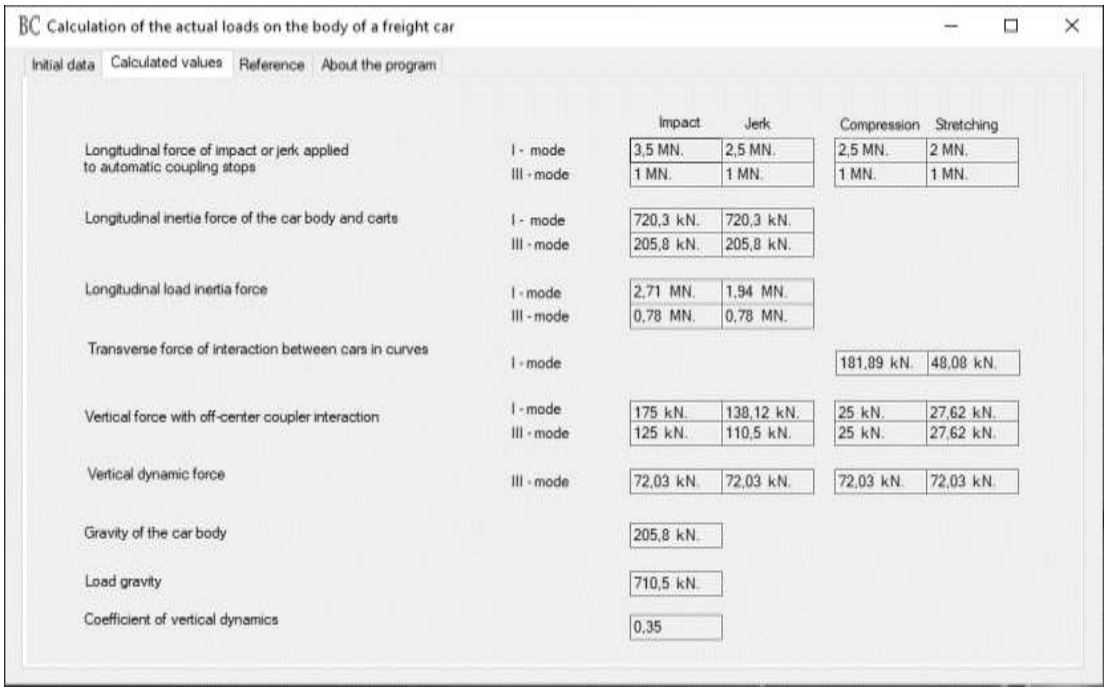

Figure 7. Window for displaying calculation results

Tab "Help" in the main form of the program is designed to provide specific assistance to the user. Here are all the necessary formulas and their values to perform the calculation.

The tab “About the program” describes the purpose of this program, its capabilities, as well as the main characteristics and limitations imposed on the scope of the program in accordance with regulatory documents.

Correct exit from the program is possible in a standard way – by clicking on the “cross” in the upper right corner of the work form.

Conclusion. Thus, the program developed in C# using the integrated environment Visual Studio has a convenient user interface and allows you to quickly calculate the loads acting on the body of the freight wagon, with strength calculations with further three-dimensional modeling with different initial technical and economic characteristics and design features freight wagons.

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